

**Električni pogonski sistemi z nastavljivo hitrostjo - 4. del: Splošne zahteve -
Specifikacije naznačenih vrednosti za pogonske sisteme na izmenično
napetost nad 1000 V in do 35 kV (IEC 61800-4:2002)**

Adjustable speed electrical power drive systems - Part 4: General requirements -
Rating specifications for a.c. power drive systems above 1000 V a.c. and not
exceeding 35 kV (IEC 61800-4:2002)

iTeh STANDARD PREVIEW
(standards.iteh.ai)

[SIST EN 61800-4:2004](https://standards.iteh.ai/catalog/standards/sist/8469cb4f-544f-469f-87ef-30e0eed910d8/sist-en-61800-4-2004)

[https://standards.iteh.ai/catalog/standards/sist/8469cb4f-544f-469f-87ef-
30e0eed910d8/sist-en-61800-4-2004](https://standards.iteh.ai/catalog/standards/sist/8469cb4f-544f-469f-87ef-30e0eed910d8/sist-en-61800-4-2004)

iTeh STANDARD PREVIEW
(standards.iteh.ai)

[SIST EN 61800-4:2004](#)

<https://standards.iteh.ai/catalog/standards/sist/8469cb4f-544f-469f-87ef-30e0eed910d8/sist-en-61800-4-2004>

English version

**Adjustable speed electrical power drive systems
Part 4: General requirements -
Rating specifications for a.c. power drive
systems above 1 000 V a.c. and not exceeding 35 kV
(IEC 61800-4:2002)**

Entraînements électriques de puissance
à vitesse variable

Partie 4: Exigences générales -

Spécifications de dimensionnement

pour systèmes d'entraînements

de puissance en courant alternatif

de tension supérieure à 1 000 V alternatif

et ne dépassant pas 35 kV

(CEI 61800-4:2002)

Drehzahlveränderbare elektrische
Antriebe

Teil 4: Allgemeine Anforderungen -

Festlegungen für die Bemessung

von Wechselstrom-Antriebssystemen

über 1 000 V AC und höchstens 35 kV

(IEC 61800-4:2002)

[SIST EN 61800-4:2004](https://standards.iteh.ai/catalog/standards/sist/8469cb4f-544f-469f-87ef-30e0eed910d8/sist-en-61800-4-2004)

<https://standards.iteh.ai/catalog/standards/sist/8469cb4f-544f-469f-87ef-30e0eed910d8/sist-en-61800-4-2004>

This European Standard was approved by CENELEC on 2002-11-01. CENELEC members are bound to comply with the CEN/CENELEC Internal Regulations which stipulate the conditions for giving this European Standard the status of a national standard without any alteration.

Up-to-date lists and bibliographical references concerning such national standards may be obtained on application to the Central Secretariat or to any CENELEC member.

This European Standard exists in three official versions (English, French, German). A version in any other language made by translation under the responsibility of a CENELEC member into its own language and notified to the Central Secretariat has the same status as the official versions.

CENELEC members are the national electrotechnical committees of Austria, Belgium, Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Luxembourg, Malta, Netherlands, Norway, Portugal, Slovakia, Spain, Sweden, Switzerland and United Kingdom.

CENELEC

European Committee for Electrotechnical Standardization
Comité Européen de Normalisation Electrotechnique
Europäisches Komitee für Elektrotechnische Normung

Central Secretariat: rue de Stassart 35, B - 1050 Brussels

Foreword

The text of document 22G/99/FDIS, future edition 1 of IEC 61800-4, prepared by SC 22G, Semiconductor power converters for adjustable speed electric drive systems, of IEC TC 22, Power electronic systems and equipment, was submitted to the IEC-CENELEC parallel vote and was approved by CENELEC as EN 61800-4 on 2002-11-01.

The following dates were fixed:

- latest date by which the EN has to be implemented at national level by publication of an identical national standard or by endorsement dop) 2003-08-01
- latest date by which the national standards conflicting with the EN have to be withdrawn dow) 2005-11-01

Annexes designated "normative" are part of the body of the standard.

Annexes designated "informative" are given for information only.

In this standard, annex ZA normative and annexes A, B and C are informative.

Annex ZA has been added by CENELEC.

Endorsement notice

The text of the International Standard IEC 61800-4:2002 was approved by CENELEC as a European Standard without any modification.

(standards.iteh.ai)

SIST EN 61800-4:2004

<https://standards.iteh.ai/catalog/standards/sist/8469cb4f-544f-469f-87ef-30e0eed910d8/sist-en-61800-4-2004>

Annex ZA
(normative)

**Normative references to international publications
with their corresponding European publications**

This European Standard incorporates by dated or undated reference, provisions from other publications. These normative references are cited at the appropriate places in the text and the publications are listed hereafter. For dated references, subsequent amendments to or revisions of any of these publications apply to this European Standard only when incorporated in it by amendment or revision. For undated references the latest edition of the publication referred to applies (including amendments).

NOTE When an international publication has been modified by common modifications, indicated by (mod), the relevant EN/HD applies.

<u>Publication</u>	<u>Year</u>	<u>Title</u>	<u>EN/HD</u>	<u>Year</u>
IEC 60034-1 (mod)	- ¹⁾	Rotating electrical machines Part 1: Rating and performance	EN 60034-1 + corr. February A 11	1998 ²⁾ 2000 2002
IEC 60034-2	1972	Part 2: Methods for determining losses and efficiency of rotating electrical machinery from tests (excluding machines for traction vehicles)	EN 60034-2	1996
A1	1995		A1	1996
A2	1996		A2	1996
IEC 60034-2A	1974	Part 2: Methods for determining losses and efficiency of rotating electrical machinery from tests (excluding machines for traction vehicles) - First supplement: Measurement of losses by the calorimetric method	EN 60034-2	1996
IEC 60034-5	- ¹⁾	Part 5: Degrees of protection provided by the integral design of rotating electrical machines (IP code) - Classification	EN 60034-5	2001 ²⁾
IEC 60034-6	1991	Part 6: Methods of cooling (IC Code)	EN 60034-6	1993
IEC 60034-7	- ¹⁾	Part 7: Classification of types of construction, mounting arrangements and terminal box position (IM Code)	EN 60034-7	1993 ²⁾
IEC 60034-9	1997	Part 9: Noise limits	EN 60034-9	1997
IEC 60034-14	1996	Part 14: Mechanical vibration of certain machines with shaft heights 56 mm and higher - Measurement, evaluation and limits of vibration	EN 60034-14	1996

1) Undated reference.

2) Valid edition at date of issue.

<u>Publication</u>	<u>Year</u>	<u>Title</u>	<u>EN/HD</u>	<u>Year</u>
IEC 60034-17	1998	Part 17: Cage induction motors when fed from converters - Application guide	-	-
IEC 60034-18-31	1992	Part 18: Functional evaluation of insulation systems - Section 31: Test procedures for form-wound windings - Thermal evaluation and classification of insulation systems used in machines up to and including 50 MVA and 15 kV	EN 60034-18-31	1994
A1	1996		A1	1996
IEC 60038 (mod)	1983	IEC standard voltages ³⁾	HD 472 S1 + corr. February	1989 2002
A1	1994		-	-
A2	1997		-	-
IEC 60050-111	1996	International Electrotechnical Vocabulary (IEV) Chapter 111: Physics and chemistry	-	-
IEC 60050-151	2001	Part 151: Electrical and magnetic devices	-	-
IEC 60050-351	1998	Part 351: Automatic control	-	-
IEC 60050-441	1984	Chapter 441: Switchgear, controlgear and fuses	-	-
A1	2000		-	-
IEC 60050-551	1998	Part 551: Power electronics	-	-
IEC 60050-601	1985	Chapter 601: Generation, transmission and distribution of electricity - General	-	-
A1	1998		-	-
IEC 60076-1 (mod)	1993	Power transformers Part 1: General	EN 60076-1 A11	1997 1997
A1	1999		A1 A12	2000 2002
IEC 60076-2 (mod)	1993	Part 2: Temperature rise	EN 60076-2	1997
IEC 60076-3 + Corr. December	2000 2000	Power transformers Part 3: Insulation levels, dielectric tests and external clearances in air	EN 60076-3	2001
IEC 60076-5	2000	Part 5: Ability to withstand short circuit	EN 60076-5	2000
IEC 60076-8	1997	Part 8: Application guide	-	-

³⁾ The title of HD 472 S1 is: "Nominal voltages for low voltage public electricity supply systems".

<u>Publication</u>	<u>Year</u>	<u>Title</u>	<u>EN/HD</u>	<u>Year</u>
IEC 60146-1-1	1991	Semiconductor convertors - General requirements and line commutated convertors Part 1-1: Specifications of basic requirements	EN 60146-1-1	1993
A1	1996		A1	1997
IEC 60146-1-2	1991	Part 1-2: Application guide	-	-
IEC 60146-1-3	1991	Part 1-3: Transformers and reactors	EN 60146-1-3	1993
IEC 60146-2	1999	Part 2: Self-commutated semiconductor convertors including direct d.c. convertors	EN 60146-2	2000
IEC 60146-6	1992	Part 6: Application guide for the protection of semiconductor convertors against overcurrent by fuses	-	-
IEC 60204-11	2000	Safety of machinery - Electrical equipment of machines Part 11: Requirements for HV equipment for voltages above 1 000 V a.c. or 1 500 V d.c. and not exceeding 36 kV	EN 60204-11	2000
IEC 60417	Series	Graphical symbols for use on equipment	EN 60417	Series
IEC 60529	1989	Degrees of protection provided by enclosures (IP Code)	EN 60529 + corr. May	1991 1993
A1	1999		A1	2000
IEC 60664-1 (mod)	1992	Insulation coordination for equipment within low-voltage systems Part 1: Principles, requirements and tests	HD 625.1 S1 + corr. november	1996 1996
A1	2000		-	-
IEC 60721-3-1	1997	Classification of environmental conditions Part 3: Classification of groups of environmental parameters and their severities - Section 1: Storage	EN 60721-3-1	1997
IEC 60721-3-2	1997	Part 3: Classification of groups of environmental parameters and their severities - Section 2: Transportation	EN 60721-3-2	1997
IEC 60721-3-3	1994	Part 3: Classification of groups of environmental parameters and their severities - Section 3: Stationary use at weatherprotected locations	EN 60721-3-3	1995
A1	1995		-	-
A2	1996		A2	1997

iTech STANDARD PREVIEW

(standards.itech.ai)

SIST EN 61800-4:2004

<http://standards.itech.ai/catalog/standards/sist/8469cb4f-544f-469f-87ef-30e0eed910d8/sist-en-61800-4-2004>

<u>Publication</u>	<u>Year</u>	<u>Title</u>	<u>EN/HD</u>	<u>Year</u>
IEC 60726 (mod) + A1 (mod)	1982 1986	Dry-type power transformers	EN 60726	2003
IEC 61000-2-4 + corr. August	1994 1994	Electromagnetic compatibility (EMC) Part 2-4: Environment - Compatibility levels in industrial plants for low- frequency conducted disturbances	EN 61000-2-4	1994 4)
IEC 61000-4-7	1991	Part 4-7: Testing and measurement techniques - General guide on harmonics and interharmonics measurements and instrumentation, for power supply systems and equipment connected thereto	EN 61000-4-7	1993 5)
IEC 61136-1 (mod)	1992	Semiconductor power converters - Adjustable speed electric drive systems - General requirements Part 1: Rating specifications, particularly for d.c. motor drives	EN 61136-1	1995
IEC 61378-1	1997	Convertor transformers Part 1: Transformers for industrial applications	EN 61378-1 + corr. November	1998 1998
IEC 61800-2	1998	Adjustable speed electrical power drive systems Part 2: General requirements - Rating specifications for low voltage adjustable frequency a.c. power drive systems	EN 61800-2	1998
IEC 61800-3	1996	Part 3: EMC product standard including specific test methods	EN 61800-3 A11	1996 2000
ISO 1680	1999	Acoustics - Test code for the measurement of airborne noise emitted by rotating electrical machines	EN ISO 1680	1999

4) EN 61000-2-4:1994 is superseded by EN 61000-2-4:2002, which is based on IEC 61000-2-4:2002.

5) EN 61000-4-7:1993 is superseded by EN 61000-4-7:2002, which is based on IEC 61000-4-7:2002.

NORME
INTERNATIONALE
INTERNATIONAL
STANDARD

CEI
IEC

61800-4

Première édition
First edition
2002-09

**Entraînements électriques de puissance
à vitesse variable –**

Partie 4:

**Exigences générales – Spécifications de
dimensionnement pour systèmes d'entraînements
de puissance en courant alternatif de tension
supérieure à 1 000 V alternatif et ne dépassant
pas 35 kV**

[SIST EN 61800-4:2004](https://standards.iteh.ai/catalog/standards/sist/8469cb4f-544f-469f-87ef-30e0eed910d8/sist-en-61800-4-2004)

<https://standards.iteh.ai/catalog/standards/sist/8469cb4f-544f-469f-87ef-30e0eed910d8/sist-en-61800-4-2004>

Adjustable speed electrical power drive systems –

Part 4:

**General requirements – Rating specifications
for a.c. power drive systems above 1 000 V a.c.
and not exceeding 35 kV**

© IEC 2002 Droits de reproduction réservés — Copyright - all rights reserved

Aucune partie de cette publication ne peut être reproduite ni utilisée sous quelque forme que ce soit et par aucun procédé, électronique ou mécanique, y compris la photocopie et les microfilms, sans l'accord écrit de l'éditeur.

No part of this publication may be reproduced or utilized in any form or by any means, electronic or mechanical, including photocopying and microfilm, without permission in writing from the publisher.

International Electrotechnical Commission, 3, rue de Varembe, PO Box 131, CH-1211 Geneva 20, Switzerland
Telephone: +41 22 919 02 11 Telefax: +41 22 919 03 00 E-mail: inmail@iec.ch Web: www.iec.ch



Commission Electrotechnique Internationale
International Electrotechnical Commission
Международная Электротехническая Комиссия

CODE PRIX
PRICE CODE XE

Pour prix, voir catalogue en vigueur
For price, see current catalogue

CONTENTS

FOREWORD	11
1 Scope	13
2 Normative references	13
3 Definitions	19
3.1 System	19
3.2 PDS input parameters	31
3.3 Converter	33
3.4 PDS output parameters	35
3.5 Control	35
3.6 Tests	37
3.7 Symbols	39
4 Overview of drive system topologies	43
4.1 Topologies classification	43
4.2 Converter configuration	43
4.3 Motor type	45
4.4 By-pass and redundant configurations	47
4.5 Regenerative and dynamic braking	49
5 Service conditions	51
5.1 Installation and operation	51
5.2 Transportation	57
5.3 Storage of equipment	59
6 Ratings	61
6.1 Power drive system (PDS)	61
6.2 Converter	67
6.3 Transformer	71
6.4 Motor	71
7 Control performance requirements	73
7.1 Steady state performance	73
7.2 Dynamic performance	75
7.3 Process control interface performance	87
8 PDS main components	91
8.1 Responsibilities	91
8.2 Transformer	91
8.3 Converter and associated controls	99
8.4 Motor	101
9 PDS integration requirements	113
9.1 General conditions	113
9.2 Integration of components with voltages above 1 000 V	119
9.3 Protection interface	127
9.4 Driven equipment interface	131
10 Tests	133
10.1 Performance of tests	133
10.2 Items of individual PDS component tests	133
10.3 Drive system tests	141

11	Efficiency determination	153
11.1	General	153
11.2	Segregated loss method	157
11.3	Full load system test	165
Annex A	(informative) Most commonly used drive system topologies	171
A.1	Object	171
A.2	Drive system topologies with indirect converters	171
A.3	Drive system topologies with direct converters	187
Annex B	(informative) Speed control performance and the mechanical system	193
B.1	General	193
B.2	Basic speed control types	193
B.3	Effect of torsion elasticity on speed control performance	195
B.4	Effects of backlash	199
B.5	Selection criteria for the speed control system	201
B.6	Specification of the speed control performance	203
Annex C	(informative) Power semiconductor losses	205
C.1	Thyristor	205
C.2	GTO/GCT thyristor (gate turn-off, gate commutated turn-off)	207
C.3	IGBT	211
C.4	Snubber losses	215
Figure 1	– Functional diagram of an a.c. adjustable speed power drive system (PDS) – Voltage above 1 kV	21
Figure 2	– Example of load envelope	35
Figure 3	– General structure of a drive system with an indirect converter	43
Figure 4	– General structure of a drive system with direct converter	45
Figure 5	– Example of multiple converter modules and separate stator winding systems motor	47
Figure 6	– Bypass configuration for system with indirect converter	47
Figure 7	– LCI-synchronous motor in a partly redundant configuration	49
Figure 8	– Example of dynamic braking	49
Figure 9	– Typical curves for efficiency and losses of a PDS at constant flux operation	65
Figure 10	– Overload cycle example	67
Figure 11	– Deviation band	75
Figure 12	– Time response following a step change of reference input – no change in operating variables	81
Figure 13	– Time response following a change in an operating variable – no reference change	83
Figure 14	– Time response following a reference change at specified rate	83

Figure 15 – Frequency response of the control – reference value as stimulus.....	85
Figure 16 – Responsibilities of the system supplier	91
Figure 17 – Insulation stressing types	107
Figure 18 – Definition of the transient voltage at the terminals of the motor	109
Figure 19 – Admissible pulse voltage (including voltage reflection and damping) at the motor terminals as a function of the peak rise time t_a	109
Figure 20 – Power drive system (PDS) – voltage above 1 000 V.....	115
Figure 21 – PDS integration.....	119
Figure 22 – Example of protective earthing and interconnection of main components	123
Figure 23 – Reference measuring points for drive system tests	143
Figure 24 – Back-to-back test	151
Figure 25 – PDS hardware configuration and individual component efficiency.....	155
Figure A.1 – Basic structure of an LCI synchronous motor drive system	171
Figure A.2 – Basic structure of an LCI induction motor drive system.....	173
Figure A.3 – Basic structure of a self-commutated PWM-CSI inverter for an induction motor drive system	173
Figure A.4 – Dual CSI-PWM converter topology for induction motor drive system	175
Figure A.5 – Three-phase VSI drive systems	177
Figure A.6 – Voltage source NPC inverter drive system	177
Figure A.7 – NPC structure.....	179
Figure A.8 – Voltage source multi-level inverter drive system	179
Figure A.9 – Multi-level inverter structure.....	181
Figure A.10 – Three-phase VSI inverter with a bi-directional line-side converter	183
Figure A.11 – Dual voltage source inverter (VSI) drive system	183
Figure A.12 – Voltage source multilevel inverter drive system	185
Figure A.13 – Power module (PM) for each level.....	187
Figure A.14 – Three-phase six-pulse connection cycloconverter with a four-winding transformer.....	189
Figure A.15 – Circulating current cycloconverter	189
Figure B.1 – Block diagram of the feedback control system containing all the basic elements	193
Figure B.2 – Mechanical diagram of a two moment inertia system	195
Figure C.1 – GTO/GCT switching waveform.....	209
Figure C.2 – IGBT switching waveform	213
Figure C.3 – Three-phase thyristor bridge circuit.....	217
Figure C.4 – Common RCD clamp	217

Table 1 – Symbols	41
Table 2 – Service conditions for the voltage supply at the PDS terminals (main and auxiliary)	51
Table 3 – Installation vibration limits	55
Table 4 – Transportation vibration limits (see class 2M1 IEC 60721-3-2)	59
Table 5 – Example of reduced maximum continuous load as a function of an overload	67
Table 6 – Maximum deviation bands (percent)	75
Table 7 – Limiting parts and typical voltage stress capability of the motor insulation system ..	111
Table 8 – PDS protection functions	129
Table 9 – Standard tests for PDS components	133
Table 10 – Standard tests of the converter as component	137
Table 11 – Drive system tests	141

iTeh STANDARD PREVIEW
(standards.iteh.ai)

SIST EN 61800-4:2004

<https://standards.iteh.ai/catalog/standards/sist/8469cb4f-544f-469f-87ef-30e0eed910d8/sist-en-61800-4-2004>

INTERNATIONAL ELECTROTECHNICAL COMMISSION

ADJUSTABLE SPEED ELECTRICAL POWER DRIVE SYSTEMS –**Part 4: General requirements – Rating specifications for a.c. power drive systems above 1 000 V a.c and not exceeding 35 kV**

FOREWORD

- 1) The IEC (International Electrotechnical Commission) is a worldwide organization for standardization comprising all national electrotechnical committees (IEC National Committees). The object of the IEC is to promote international co-operation on all questions concerning standardization in the electrical and electronic fields. To this end and in addition to other activities, the IEC publishes International Standards. Their preparation is entrusted to technical committees; any IEC National Committee interested in the subject dealt with may participate in this preparatory work. International, governmental and non-governmental organizations liaising with the IEC also participate in this preparation. The IEC collaborates closely with the International Organization for Standardization (ISO) in accordance with conditions determined by agreement between the two organizations.
- 2) The formal decisions or agreements of the IEC on technical matters express, as nearly as possible, an international consensus of opinion on the relevant subjects since each technical committee has representation from all interested National Committees.
- 3) The documents produced have the form of recommendations for international use and are published in the form of standards, technical specifications, technical reports or guides and they are accepted by the National Committees in that sense.
- 4) In order to promote international unification, IEC National Committees undertake to apply IEC International Standards transparently to the maximum extent possible in their national and regional standards. Any divergence between the IEC Standard and the corresponding national or regional standard shall be clearly indicated in the latter.
- 5) The IEC provides no marking procedure to indicate its approval and cannot be rendered responsible for any equipment declared to be in conformity with one of its standards.
- 6) Attention is drawn to the possibility that some of the elements of this International Standard may be the subject of patent rights. The IEC shall not be held responsible for identifying any or all such patent rights.

International Standard IEC 61800-4 has been prepared by sub-committee 22G: Semiconductor power converters for adjustable speed electric drive systems, of IEC technical committee 22: Power electronic systems and equipment.

The text of this standard is based on the following documents:

FDIS	Report on voting
22G/99/FDIS	22G/107/RVD

Full information on the voting for the approval of this standard can be found in the report on voting indicated in the above table.

This publication has been drafted in accordance with the ISO/IEC Directives, Part 3.

Annexes A, B and C are for information only.

The committee has decided that the contents of this publication will remain unchanged until 2008. At this date, the publication will be

- reconfirmed;
- withdrawn;
- replaced by a revised edition, or
- amended.

ADJUSTABLE SPEED ELECTRICAL POWER DRIVE SYSTEMS –

Part 4: General requirements – Rating specifications for a.c. power drive systems above 1 000 V a.c. and not exceeding 35 kV

1 Scope

This part of IEC 61800 applies to adjustable speed a.c. drive systems that include power conversion, control equipment and a motor. Excluded are traction for railway applications and electrical vehicle drives.

It applies to power drive systems (see figure 1) with converter voltages (line-to-line voltage), between 1 kV a.c. and 35 kV a.c., input side 50 Hz or 60 Hz, and load side frequencies up to 600 Hz. Requirements for voltages above 15 kV are not included and are defined by agreement between the manufacturer and the system supplier.

For power drive systems, with voltages above 1 kV, using a step-down input transformer and/or a step-up output transformer in connection with a low voltage converter (below 1 000 V), IEC 61800-2 applies.

EMC aspects are covered in IEC 61800-3.

Specific safety requirements for drive systems with voltage above 1 kV will be covered in IEC 61800-5.

This standard gives the characteristics of the converters, their topologies and their relationship with the complete a.c. drive system. It also states their performance requirements with respect to ratings, normal operating conditions, overload conditions, surge withstand capabilities, stability, protection, a.c. line earthing, topologies and testing. Furthermore, it deals with application guidelines, such as control strategies, torsion analysis, recommendations for earthing and drive system component integration.

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

IEC 60034-1, *Rotating electrical machines – Part 1: Rating and performance*

IEC 60034-2:1972, *Rotating electrical machines – Part 2: Methods for determining losses and efficiency of rotating electrical machinery from tests (excluding machines for traction vehicles)*
Amendment 1 (1995)
Amendment 2 (1996)